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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

DIRECT SUPPORT MAINTENANCE
STRUCTURES FOR
ARMY MISSILE SYSTEMS

STUDY PROJECT REPORT
PMC 77-1

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DIRECT SUPPORT MAINTENANCE STRUCTURES FOR ARMY MISSILE SYSTEMS

Individual Study Program

Study Project Report

Prepared as a Formal Report

Defense Systems Management College

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by

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May 1977

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: Direct Support Maintenance Structures for Army Missile Systems

STUDY PROJECT GOALS: Identify and define the conceptual basis for DS Maintenance structures for Army missile systems and analyze organizational influence on operational readiness/availability.

STUDY REPORT ABSTRACT: Current Army policies and doctrine for maintenance support of missile systems is examined. The organizational impact of DS maintenance support structure on supply dispersion, responsiveness and distance to supported unit in relationship to operational availability as developed. Six alternative variations of organic and area support are examined. It is concluded that no single DS maintenance support structure is best for all missile systems but that the factors impacting on operational availability, relative economy and Program Management Office management difficulty must be considered in the selection of DS maintenance.

SUBJECT DESCRIPTORS: DS Missile Maintenance, Operational Availability, Material Maintenance, Missile Systems, Force Structure, Direct Support Maintenance Missile Maintenance.

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EXECUTIVE SUMMARY

Current Army policies and doctrine for maintenance support of missile systems is examined. The organizational impact of DS maintenance support structure on supply dispersion, responsiveness and distance to supported unit in relationship to operational availability is developed. Six alternative variations of organic and area support are examined. It is concluded that no single DS maintenance support structure is best for all missile systems but that the factors impacting on operational availability, relative economy and Program Management Office management difficulty must be considered in the selection of DS maintenance.

LIST OF FIGURES

SECTION I

INTRODUCTION

1. Purpose and Goal.

a. US Army policy on maintenance engineering in the acquisition process specifies that as design development progresses: (1) quantitative analytical techniques and cost effectiveness studies will be used to make repair or discard, level of repair, life-cycle maintenance costs and related determinations; and, (2) identify further economic or operational advantages that can be realized in the design of the maintenance support structure for the system. (2, 2-4)

b. The purpose of this paper is to explore the alternatives for design of the maintenance support structure for missile systems, specifically those for direct support. Development of alternative DS maintenance support structures is accomplished by Program Management Offices (PMOs) in conjunction with the Combat Developer, Logistician and Trainer. Events 4, Logistics Support Planning and Event 25, Update Logistic Support Analysis and Planning of the Life Cycle System Management Model address this requirement (21, C-3 and C-6).

c. The formulation of maintenance support concepts involves the provision of support which is both effective and economical. The support provided is normally limited to that which is sufficient to satisfy operational requirements. Maintenance elements are staffed for average work load, either annual maintenance manhour requirements or maintenance manhours based on usage. In either case efficiency of operation is the driving criteria e.g., staff for average requirements. In these cases

operational availability is a resultant figure rather than the driving force in concept development. When maintenance organizations are staffed on an economic base utilizing average requirements, the user and ILS planner must be willing to accept fluctuations in operational availability. If the maintenance effort is staffed for the average work load; operational availability will vary in inverse proportion to equipment usage or combat activity, as the maintenance support structures will become over loaded with equipment requiring maintenance and overall operational availability rates will decline. During relatively inactive periods there will be more maintenance capability than that required and availability rates will tend to increase. Staffing for the peak periods is uneconomical in that it allows for efficient utilization of maintenance resources only during those peak periods. The formulation of maintenance concepts to insure high availability rates at all times necessarily involves the allocation of maintenance resources to accommodate peak periods of activity. This method should be reserved for conditions or situations when operational availability is the driving factor and overrides economic considerations and maintenance operations are the only means to achieve the desired operational availability. Because of their large contribution to the field Army's combat power and their relatively low density, some missile systems fall into this category.

d. A second major problem encountered when examining maintenance concepts for missile systems is that the maintenance concept should influence equipment design rather than be an after action when systems are fielded. Once fielded a piece of equipment will have certain physical characteristics which must be satisfied by the supporting maintenance

structure. If modularized replacement is to be a major basis for support then the equipment design must accommodate modular replacement. If operational availability is paramount and an item of equipment relies heavily upon piece part repair then that capability must be located at the lower categories of maintenance. Operational availability requirements may require a downtime of such short duration that only providing a maximum repair capability at the organizational level will satisfy the requirement. Thus the design characteristics of the missile systems involved in this analysis must be taken into account in determining the most effective maintenance support structure for each system.

2. The maintenance support for missile systems requires some unique features because of their critical mission, their complexity, their relative low density, and the requirement for constant high operational readiness rates. Therefore, this analysis must not only consider the support problems outlined above, but must recognize these unique features of missile maintenance support. Although the methodology of this analysis may be applied to the examination of maintenance support for other Army materiel the conclusions and recommendations are presented only for missile systems and are predicated upon their particular characteristics.

3. Definitions

a. Area Support - As applied to DS maintenance, it is support provided by a maintenance unit to elements in or passing through a specified geographic area.

b. Mean Time to Repair (MTTR) - The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

c. Operational Ready - As applied to equipment - available and in condition for serving the functions for which designed (12, 1-4).

d. Operational readiness/unit readiness - the capability of a weapon system to perform the missions or functions for which it is organized or designated (12, 1-4).

e. Operational ready essential item - An item of equipment, which must be present, on site, in an operable condition in order for a "pacing item" missile system to perform its combat mission and the absence or failure of which would jeopardize or seriously degrade the primary weapon system's capacity to perform that mission. It is an item which cannot be replaced, by-passed, or otherwise declared non-essential as a result of the responsible commander being able to accomplish the mission utilizing some other resources (e.g., operational readiness float, direct exchange, substitution of similar equipment, cross leveling of supplies, increased readiness of other equipment or units, or increased manpower). Identification of operational readiness essential items should initially be made in conjunction with the combat developer development of the support concept phase.

f. Organic Support - As applied to DS Maintenance, it is maintenance support which is provided by the using unit to itself.

g. Pacing items - major equipment systems which pace Army readiness, as a whole, and which require close and continuous monitoring from unit to Department of the Army level (24, B-1).

4. Assumptions

a. Personnel assigned to DS maintenance are equally and adequately trained regardless of the organizational structure to which assigned.

b. The time for a given repairman to correct a fault is dependent on skill, training and equipment and is independent of the DS organizational structure.

c. Previous analysis in maintenance support planning considering repair or discard and level of repair tradeoffs, the complexity of the missile system, the operational environment of the mission profile, and the criticality of the missile system has established that a DS maintenance organization is required for support of the missile.

SECTION II

CURRENT STRUCTURES/CONCEPTS FOR DS MAINTENANCE OF MISSILE SYSTEMS

1. Doctrine. FM 29-20 Maintenance Management in Theaters of Operation and FM 9-59 Missile Support Unit Operations outline the organization for and operation of missile maintenance elements within a theater of operations. These manuals distinguish between the support concept for high cost, low-density missile systems and medium cost, high density missile systems.

a. Direct support of high cost, low-density missile systems e.g., HAWK, Nike Hercules, Pershing and Sergeant, is provided by missile direct support elements organic to the air defense or artillery battalion. These elements provide direct maintenance support for the missile peculiar items; that is, no support is provided for COMSEC, vehicles, warhead adaption kits, or warhead sections, etc.

b. Direct support of medium cost, high-density missile systems e.g., Shillelagh, TOW, Dragon, Redeye, Chaparral, and Lance is provided on an area support basis by missile support detachments/companies. These detachments/companies may be assigned or attached to an ammunition battalion, ammunition company, maintenance battalion, or to a guided missile general support company. The detachments also have the capability to provide general support.

2. AR 750-1, "Army Materiel Maintenance Concepts and Policies".

a. AR 750-1 provides that, although combat service support units will ordinarily be organized to provide functionalized service, maintenance support of high priority weapons systems such as aircraft and missiles

will normally be system-peculiar or commodity-oriented. Further, "whenever practicable and cost effective, system-peculiar and commodity-oriented maintenance support units will have the capability of performing both direct support and general support maintenance operations" (14, 4-2d).

b. AR 750-1 also authorizes the assignment of an organic capability for support maintenance to operational units because of the design characteristics or limited distribution (low density) or operational requirements (high operational availability) of items of equipment (para 1-11). "In developing concepts for the maintenance support of specific commodities or weapons systems, consideration will be given to tailoring this functionalized support structure to the particular commodity or system. This will assure the most effective and efficient use of maintenance resources in sustaining the required degree of operational availability of the item." "(14, 2-4b) The development and application of concepts which tailor the basic maintenance support structure to specific commodities or weapons systems must recognize the ..." (14, 2-4c) They are:

(1) Complexity of the system or equipment.

(2) Mobility requirements and maximum permissible downtime for maintenance.

(3) Critical skill requirements.

(4) Operational environment and mission responsibilities of the field commanders.

(5) Criticality of the system or equipment to the accomplishment of these mission responsibilities.

c. AR 750-1, Appendix B, Maintenance Concepts for Electronics

Equipment (includes missile) outlines the following responsibilities:

(1) Organizational maintenance will include preventive maintenance, external adjustments, operational checks and calibration of equipment and external cable assemblies. Analysis of a malfunction will be to the defective module. Repair is limited to replacement of modules which are easily removed/installed.

(2) Direct support maintenance concentrates on the repair of end items for return to the user and the limited repair of modules for the direct exchange program. Repairs authorized are the replacement/repair of modules and repairs to end items which can be accomplished efficiently and effectively with easy to use and interpret tools and test measuring diagnostic equipment (TMDE). Repair of equipment is limited to the using of limited conventional piece-parts and by the application of authorized repair kits. It provides quick reaction maintenance support to organizational maintenance through maximum use of direct exchange and/or operational readiness float items and provides forward maintenance support and technical assistance through use of mobile maintenance contact teams on a periodic or as-required basis, to make instrumental performance tests, alignment, repair, replacement, or on-the-job training.

(3) General support maintenance concentrates on the repair of unserviceable modules in support of the direct exchange service provided to designated lower categories of maintenance, support of the theater/Army maintenance program, operational readiness float activities and repairs items for return to the theater/Army supply system. It replaces defective modules beyond the capability of skills, tools, test, measurement, and diagnostic/fault isolation equipment of lower levels and evacuates un-

serviceables to designated repair facilities. Repair of modules including wired/printed circuit boards/cards, constructed of conventional piece-parts and/or selected solid state integrated circuits is accomplished at the GS level.

SECTION III

OPERATIONAL AVAILABILITY

1. Before various structure for the missile maintenance systems can be examined, the factors that contribute to or degrade operational availability must be clearly identified and examined in detail. Availability may be looked upon in two perspectives: That availability which is the goal of equipment designers, and that which is achieved by a deployed system or item of equipment. Army TM 38-710, Integrated Logistics Support, Implementation Guides for DOD Systems and Equipments (20, VII-14) recognizes three availability relationships:

a. Inherent availability (Ai) is the probability that a system or equipment, when used under stated conditions in an ideal support environment, (e.g. available tools, spares, manpower, etc.), shall operate satisfactorily at a given point in time. Inherent availability excludes scheduled (preventive) maintenance actions logistics supply time, and administrative down time.

b. Achieved availability (Aa) is defined as that probability that, when used under stated conditions in an ideal support environment, a system or equipment operate satisfactorily at a given point in time. This concept includes preventive maintenance actions but excludes logistics supply time and administrative downtime.

c. Operational availability (Ao), is defined as the probability that, when used under stated conditions in an actual support environment, a system will operate satisfactorily at any time. Ao is characteristic of a fielded system and includes delay time considerations within the down

time of a system.

2. These three types of availability have different uses. The first two Ai and Aa, are primarily the tools used in development and initial production testing and reflect the extent to which the contractor has achieved maintainability by his design of a system. (13, 2-2) Operational availability on the other hand is the characteristic of the deployed system. Because inherent availability and achieved availability both presuppose an "ideal support environment" and exclude delay time, their applicability for an examination of the impact of the direct support organization on the fielded system is inappropriate. Operational availability on the other hand is the availability achieved by a fielded system under actual support environments and is used for operational testing, life cycle costing, and force development (13, 2-2). Operational availability (Ao) will be used as a basis for examination of missile maintenance support DS structures.

3. a. Operational availability definitions

(1) In TM 38-710, operational availability, is expressed as the relationship between mean time between maintenance (MTBM) and mean down time (MDT). In TM 38-710 this is stated as:

$$Ao = \frac{\text{MTBM + ready time}}{(\text{MTBM + ready time}) + \text{MDT}} \qquad (20, \text{VII-17})$$

MTBM is the mean time between required maintenance actions. These include both the mean time between failure (i.e., unscheduled maintenance actions) and mean time between preventive actions (i.e., scheduled maintenance actions).

(2) In the RAM Handbook for the Combat Developer, operational availability is defined as:

$$Ao = \frac{OT + ST}{OT + ST + TPM + TCM + ALDT} \qquad (22, 1\text{-}3)$$

where OT = Operate Time

ST = Standby Time

TPM = Total Preventive Maintenance Time

TCM = Total Corrective Maintenance Time

ALDT = Total Administrative and Logistic Delay Time

(3) In AR 702-3, Army Materiel Reliability, Availability, and Maintainability (RAM), operational availability is defined as:

$$Ao = \frac{\text{Uptime}}{\text{Uptime + down time}}$$

$$\text{or} \quad = \frac{\text{operating time + non operating time}}{\text{operating time + non operating time + down time}}$$

b. While the three definitions of operational availability vary, in description of time in which the system is in use, or available for use, all three are consistent in the description of down time. The description and definition of those times other than down time is not germane to this paper, as those times are not influenced by the DS maintenance organization. However, the early definition of operating and nonoperating times through agreement with the combat developer on operating cycle, mission profiles, failure definition, etc. is important, in order to preclude differing interpretations of test results. Times other than down time are influenced by design reliability, manufacturing quality, operational employment concepts, and operator errors. A maintenance induced failure, e.g. an incorrect action by a repairman, could influence the time between periods of downtime; however, these induced failures can be attributed to the training base and the quality of supervision,

which are independent of the DS maintenance organizational structure.

c. This discussion is focused on direct support maintenance organization, but it should be noted that the availability relationship determines the potential trade offs between design reliability and maintainability criteria and the logistic structure during the validation/demonstration and full scale engineering development phases of the missile systems life cycle.

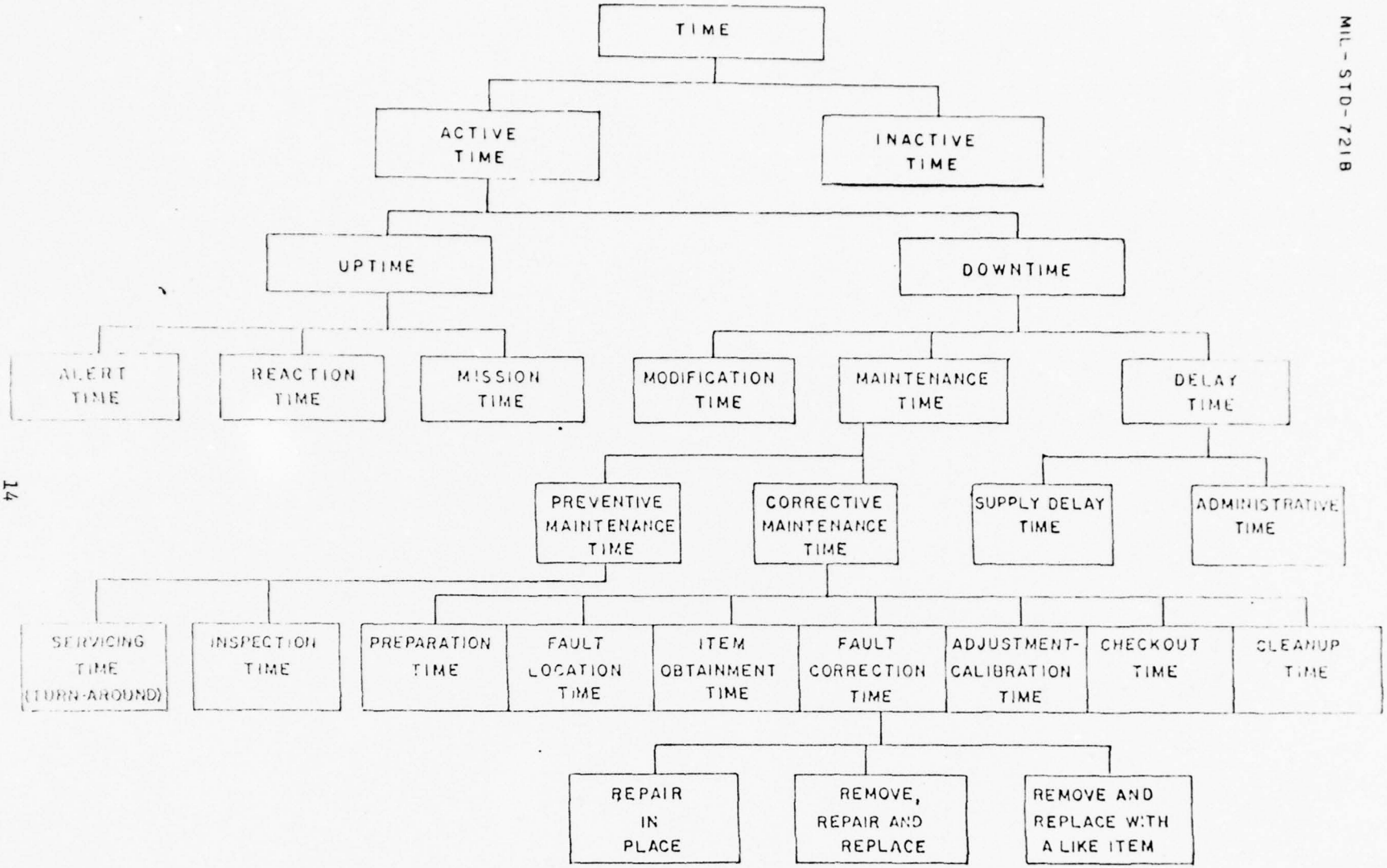
d. Mean down time can be considered to include all time during which the item is not in condition to perform its intended function (11, 9). It is in the area of mean down time that the operational availability of a system may be influenced by the maintenance concept, or doctrine, and the organization for accomplishing maintenance. In order to analyze Ao it is necessary to examine, in greater depth, factors contributing to down time. Both Mil-Std-721B, Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety and the RAM Handbook for the Combat Developer portray time trees which are consistent. The tree from Mil-Std-721B is presented in Figure 1. (10, 14)

e. Modification Time is the time in which the system is not operational due to changes being applied to the system to improve its characteristics or to add new ones, such as through the Product Improvement Program. Modification time is not included in computation for operational availability.

f. Maintenance Time

(1) Preventive Maintenance Time is dependent on usage of the equipment itself and not affected by the DS maintenance organization.

(2) Corrective Maintenance time elements are considered to be hardware



TIME RELATIONSHIP

Figure 1

dependent and constant factors because the time required to perform each one should not vary with a change in the organization for maintenance nor the maintenance system. MTTR in the availability formulae are a measure of the mean corrective maintenance time for a system.

(a) Preparation time is the time the mechanic or inspector requires to obtain the manuals and set up any equipment necessary to begin his procedures for locating or isolating the equipment fault.

(b) Fault location time includes the time required for testing and analyzing an item to isolate a malfunction or fault. As with preparation time, this should not vary with the organization for maintenance but will vary with the skill of the repairman trouble shooting the equipment, or with the test and diagnostic equipment available for his use.

(c) Item obtainment time is the active time required to obtain needed supply items or repair parts from the unit's internal supply source. This element should not be confused with the time required to obtain supply items from external sources. It is determined by internal organization and techniques and is not dependent on the supporting logistics structure.

(d) Fault correction time is perhaps the most familiar element of down time. As an element of down time it includes that time during which the mechanic or repairman is actively engaged in a repair function to correct the malfunction. It may consist of correcting the malfunction with the faulty item in place, removing and replacing the item with a like serviceable item, or removing the item for corrective action and reinstalling the same item. The time to perform a repair or replacement function should not vary with the maintenance organization as it is inherently dependent on the physical maintainability characteristics of

the item. Without a design change the time to perform a repair function on any particular item of equipment will not vary with a change in repair location.

(e) Adjustment-time is the time to make any adjustments and accomplish the calibration necessary to place the item in its final operational condition.

(f) Final test time is the final action taken to insure that the repaired item functions satisfactorily.

(g) All of these corrective maintenance time elements are directly related to the physical characteristics and maintenance requirements of the equipment. They will not vary because of the type organization for DS maintenance.

(3) In discussing the elements of maintenance time it must be continually stressed that they are hardware dependent and do not vary between organizations (i.e., are not influenced by the organization for maintenance). In other words, a given mechanic, supplied with the proper tools and equipment, should be able to perform a given maintenance function whether preventive or corrective in the same time regardless of the organization for maintenance. The implied assumption is that the mechanics are equally trained and that proper tools and equipment are equally available to him.

g. Delay Time. The second major element of down time is delay time during which no corrective or preventive action is being accomplished on the item because of either supply or administrative reasons. Upon examination of delay time there appears to be variables that may cause a fluctuation in operational availability due to the organizational structure.

Elements of delay time include those delays, or periods of inoperability, due to administration of maintenance and supply, unavailability of tools, test equipment and repair parts, and other such delays not directly attributable to active corrective or preventive maintenance actions.

(1) Supply delay time is that portion of delay down time during which a needed item is being obtained from other than the stockroom within the maintenance organization. In general, the responsiveness of the supply system is dependent on the quantity of repair parts available, the number of sites in which the repair parts are stocked, and the visability, control and accessability of repair parts by inventory management procedures. In total, these could be combined into a term called supply dispersion. In this analysis the impact of the organizational concept on supply dispersion will be analyzed. An organization which requires or has the characteristic of low supply dispersion would require fewer quantities of repair parts, stocked in fewer locations and with less complex inventory management procedures required. Distance between supporting and supported units could be considered a factor in supply delay however it will be treated later as an administrative delay factor.

(2) Delay time attributable to administrative factors include many elements that may or may not vary between organizations. To determine the cause for the variance in down time brought about by administrative factors it is necessary to identify each one and determine what influences these factors. There are many actions and functions that take place within any maintenance activity which are either maintenance related, or necessary for other reasons, none of which are directly productive in the maintenance effort.

(a) Included in non-maintenance related activities might be alert duties, unit inspections, unit roster type duties, and unit training (non-maintenance subjects). There is no question that this type of activity is present in all types of units and that they do produce down time as they do reduce the time that a mechanic or repairman can be actually maintenance productive. The question then, is to what degree do these nonproductive factors influence down time? What determines what percentage of the time available is spent on these non-maintenance related tasks? Because these factors are not hardware dependent, and are performed in all maintenance activities (may vary from unit to unit) they must be dependent upon some intangible aspect rather than the organization. It is the unit's mission, the urgency of the maintenance requirement, the commander's influence and personality, and maintenance priorities that cause these factors to vary. The consideration at this point is to recognize that these factors do exist, they are not dependent upon the physical characteristics of the materiel supported or support unit organization, and that they do vary from unit to unit. (23, I-8)

(b) Of significance concerning operational availability are those nonproductive but maintenance related administrative factors that contribute to down time. Directly related to the time a repairman is available for "hands-on" maintenance are various tasks and functions that detract from this available time. These include, but are not necessarily limited to: Maintenance training designed to cross-train or better train a repairman; maintenance meetings, either formal or informal; maintenance on tools and test equipment; time spent in the operation of tool cribs; time spent in storage, issuing, handling, loading, unloading, processing, and deprocess-

ing equipment; the time spent operating vehicles and equipment assigned to the maintenance organization including operator maintenance, and travel time to, from, or between maintenance jobs. All of these administrative functions occur at all maintenance activities and reduce productive time available to perform maintenance. Other administrative delays fall into the categories of preventing active maintenance operation. They involve the time delay or lags due to the capacity of maintenance units. One of these type of delays is awaiting shop space. This occurs when personnel and facilities are overloaded and a piece of equipment must wait for shop space. Another delay in active maintenance operations occurs when time is lost due to awaiting special equipment or tools. In some cases severe weather may also cause an interruption or delay in maintenance activities. Again these nonproductive but maintenance types of delay are not influenced by organizational structure but with the exception of weather are controlled by priorities and command influence.

(c) The element of the distance between equipment (operating unit) and its maintenance support impacts on delays. The further an item is located away from its support the greater will be the down time attributable to awaiting maintenance assistance, evacuation time, or the time required to return a repaired item to the owning unit. Also, greater time will be required for replenishment of repair parts from the maintenance unit's technical supply to the using unit. For maintenance support to be responsive it cannot be located so far from the supported unit as to create unwarranted delays. The optimum distance has not been determined and perhaps cannot be due to the variables involved. Certainly the intensiveness of the combat situation, enemy capabilities, etc. will

dictate the appropriate distance. Thus a balance must be drawn to allow quick maintenance response but provide some degree of security to maintenance service. Proximity to support will be analyzed with respect to the organizational influence on Ao.

(d) A final influence on the extent of administrative delay time is the amount of resources allotted for the maintenance operation in question. An increase in the personnel and materiel resources to accomplish a particular maintenance support function without an increase in the maintenance requirement - will reduce the down time attributable to administrative delay simply because delays and lag times will be reduced. The increase of resources is, of course, a means to improve operational availability through a reduction in administrative delay time. However, there are several important factors that must be considered before this action is taken. An increase in resources applied results in a direct increase in operating and support (O&S) costs. Further, operational availability will not necessarily increase in direct proportion to the increase in resources. Initially an increase in resources will increase Ao. However, as resources are increased the percentage of Ao increase will lessen until a saturation point is reached where Ao will not increase regardless of what resources are applied. The effect of increasing resources is the same as staffing and equipping units with test equipment to accommodate the maintenance requirement at the peaks when normal structuring is done to accommodate average work loads. Staffing and equipping for peak periods is inefficient. Regardless of the concept employed or the support structure utilized Ao can be increased with an increase in resources. The resources required for implementation of

various DS structures will be considered in terms of relative economy of personnel and test equipment. For a desired level of operational availability the relative economy will be greater if it requires fewer skilled personnel and less test equipment.

4. Delay Time Impact.

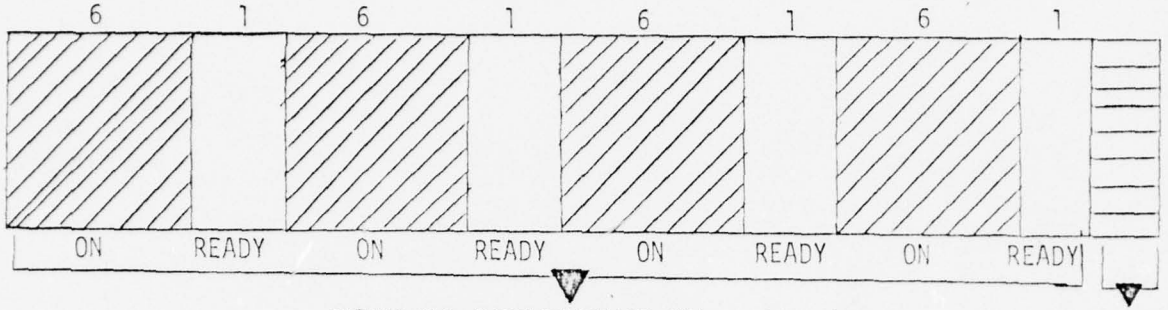
a. Upon examination of the factors or elements of down time in determining operational availability it becomes apparent that by eliminating those factors that are dependent upon the physical characteristics of the equipment in question, it is delay time that offers the most promising area for investigation and analysis of the influence of organizational structures. Operational availability is expressed as $Ao = \frac{MTBM + \text{ready time}}{MTBM + \text{ready time} + MDT}$. MDT includes active repair time, administrative wait time, and down time due to logistics supply inadequacies. (20, VII-17)

b. The expression of Ao in this manner allows the manager to determine what impact each of the elements has on Ao and to measure the results when the factors are varied. Figure 2 portrays the operating profile of a subsystem of missile system. Figure 3 portrays the impact on operational availability when MTTR (Case 2), MTBF (Case 3), and Mean Delay Time (Case 3) are improved by a factor of two. The more significant improvement in Ao when a reduction in Mean Delay Time from 1 hour to 1/2 hour as opposed the lesser improvement in Ao when MTBF is increased from 50 to 100 hours should be noted. This portrays the importance to the PMO of the factors which influence mean delay time in the satisfaction of user requirement for operational availability.

5. The preceding discussion has demonstrated that once an item or system

AVAILABILITY EXERCISE

ASSUMES A GROUND RADAR THAT HAS POWER ON FOR 6 HOURS AND IS THEN IN A READY CONDITION FOR 1 HOUR BEFORE FULL OPERATION FOR ANOTHER 6 HOURS.



TIME TO PREVENTIVE MX = 24 HRS
(TIME EQUIPMENT IS ON)

TIME TO PERFORM PREVENTIVE MX = 3 HRS

TOTAL CYCLE = 31 HRS

MEAN TIME BETWEEN FAILURE = 50 HRS

MEAN TIME TO REPAIR = 2 HRS

MEAN DELAY TIME = 1 HR

Figure 2

IMPACT ON OPERATIONAL AVAILABILITY

	OPERATING TIME	READY TIME	MPT	MTBMs	MTBF	MTTR	MEAN DELAY TIME	Ao
Case 1	24	4	3	24	50	2	1	.842
Case 2						1		.866
Case 3					100			.857
Case 4							.5	.864
Case 5	12	16						.897

Figure 3

is fielded the hardware characteristics will determine its maintainability. The structure or organization for DS maintenance has little or not influence on these maintenance requirements. In other words, the mean time between failures, mean time to repair, and scheduled maintenance periods remain fixed and will not significantly vary between DS maintenance structures, provided the same maintenance skills and the required tools and equipment are present. It is in the area of delay time attributable to administration and supply that variances are found in the field, which can cause increases or decreases in operational availability. Specific factors impacting on delay time are distance, supply dispersion, and responsiveness.

SECTION IV

ALTERNATIVE STRUCTURES FOR DS MAINTENANCE OF MISSILE SYSTEMS

1. The alternative DS structures identified below vary in the degree of maintenance responsibility assigned to either the maintenance support organization or the missile firing battalion (user). Alternatives range from the provisioning of the total direct maintenance support by an area maintenance support structure to assigning a full direct support maintenance capability organic to the user.

2. Description of identified direct support structures.

a. Total Area Support, Alternative 1. Provide total direct maintenance support from the area maintenance support structure. Under this concept all direct support maintenance requirements of the missile units will be provided, on an area basis, by the normal DS maintenance structure. Missile maintenance would be provided by the nearest, designated on an area basis, missile direct support maintenance element (detachment or company), on a maintenance request or contact team basis as there would be no element habitually dedicated to an individual unit. Maintenance support for non-missile items would be provided similarly from direct support maintenance battalions. This is the support concept presently employed for medium cost, high density missile systems e.g., Shillelagh, TOW, Dragon, Redeye, Chaparral, and Lance.

b. Missile Dedicated Area Support, Alternative 2. This alternative depends upon the area maintenance support structure for the maintenance of both missile and non-missile items except that DS missile maintenance will be provided on a dedicated basis. DS maintenance teams or detach-

ments, although assigned to the area maintenance support structure, will be colocated with the missile firing battalion. Their maintenance efforts will be dedicated to their user and will be limited to missile peculiar items. Maintenance for all non-missile peculiar items will be furnished from other DS units in the area maintenance support structure.

c. Readiness Dedicated Area Support, Alternative 3. Another alternative which depends heavily upon the area maintenance support structure resembles alternative 2 above, except the extent of dedicated maintenance is expanded. In this case, the maintenance furnished by the dedicated maintenance element will include DS level maintenance for the missile unit's equipments which are considered "operational ready essential". Thus, if a non-missile peculiar item of support equipment is determined to be essential to the attainment of the required missile availability rates it will receive direct support maintenance from the dedicated maintenance element.

d. Missile Organic Support, Alternative 4. The alternatives described above assigns maintenance responsibility to the area maintenance structure. However, this alternative provides an organic missile peculiar DS maintenance capability to the missile unit. Maintenance for all non-missile peculiar items will continue to be provided by the area maintenance structure. This alternative is the concept currently employed for the Nike Hercules, HAWK, PERSHING, and SERGEANT missile systems which have a missile peculiar maintenance capability organic to the missile battalions.

e. Readiness Organic Support, Alternative 5. This alternative is similar to (d) above, except that it provides a slightly greater maintenance

capability organic to the missile unit. This alternative would provide the missile battalion with an organic capability to perform direct support maintenance on all of its equipment determined to be essential in sustaining a high missile operational availability. This would include all missile peculiar items plus those items satisfying the operational readiness essentiality criteria. Maintenance for all other items would be provided by the area maintenance structure.

f. Total Organic Support, Alternative 6. The sixth alternative rests directly opposite from alternative 1. In this alternative a full direct support maintenance capability - for all its equipment - would be assigned to the missile firing battalion. This missile battalion would be entirely independent of the area maintenance support system as far as direct support maintenance is concerned. The only maintenance received by this missile battalion from the area maintenance structure would be at the general support level.

3. The above alternatives consider only the battalion as the basic missile employment organization. Additional alternatives could be developed which would consider other levels of the tactical organization to be the basic missile organization. For example, an alternative could be to assign a full organic DS maintenance capability to the missile firing battalions next higher headquarters (e.g., air defense brigade/group). This would be somewhat between alternative 1 and 6 from the perspective of the missile firing battalion commander, and similar advantages and disadvantages would accure.

SECTION V

DISCUSSION OF ALTERNATIVE ADVANTAGES AND DISADVANTAGES

1. DESCRIPTION: Total Area Support, Alternative 1

a. ADVANTAGES:

(1) This alternative essentially describes a centralized maintenance system. Centralization allows for the consolidation of skills, personnel, and maintenance equipment at key locations for area support. This consolidation results in an economic savings through a reduction of personnel and equipment and the efficient utilization of both.

(2) This concept standardizes missile support with the support of other commodities under the functionalized maintenance system.

(3) Retention of the maintenance personnel in the maintenance structure should insure a higher utilization of their skills in maintenance mission oriented tasks.

(4) Under this concept the tactical commander is not directly burdened by the day-to-day responsibility of support maintenance operations.

(5) The repair parts mission is of sufficient magnitude to allow the maintenance unit commander some degree of flexibility in shifting resources to meet changing priorities or respond to sudden changes in maintenance requirements.

(6) Reduction in the total amount of supplies can be achieved by reduction in the number of stockage lists.

(7) This alternative is relatively easy to develop for the PMO as

the number of combat development elements with which coordination must be accomplished is small. However, other commodity areas must be coordinated with for support.

b. DISADVANTAGES:

(1) The missile unit would have to compete with other units for maintenance support priorities. While this may not be particularly important concerning the maintenance of non-missile items it could prove significant in the attainment of high operational availability of the missile items. With centralization of missile maintenance, there may be insufficient maintenance resources to perform missile maintenance, on a high priority basis, for all supported missile units.

(a) The maintenance unit commander is not fully aware of tactical priorities from one firing unit to another and cannot provide support flexibility to fulfill all the requirements dictated by changing mission priorities. He cannot insure that missile logistical support is provided priority consideration that is commensurate with the tactical priorities established by tactical commanders. The time and coordination required to shift priorities may reduce response times.

(b) The maintenance unit commander, at this level, is not fully aware of resource requirements on a day-to-day basis as dictated by tactical developments. This may cause a resource distribution lag.

(2) Maintenance provided on a request basis from the area support structure reduces reaction time. This slower response time increases the down time attributed to administration and supply delay times. This concept does not provide the immediately responsive maintenance support required to support high priority missile systems, which require high

availability rates.

(3) Under this concept the distance between supporting and supported unit will necessarily increase maintenance delay times.

(4) Reaction times may increase due to the lack of urgency normally associated when supporting and supported units functioning under separate command channels. In this case, the maintenance unit does not become "personally involved" with the combat unit. Further, the units operate on different communication nets which will cause a delay in response time.

2. DESCRIPTION: Missile Dedicated Area Support, Alternative 2

a. ADVANTAGES:

(1) Many of the advantages cited for Alternative 1, also apply to Alternative 2:

(a) The maintenance unit commander retains control of his maintenance resources.

(b) As the maintenance unit commander controls all of the logistical resources, he has full control of their proper management and distribution.

(c) Personnel skills are more likely to be utilized in maintenance mission oriented tasks.

(d) This concept does not require the tactical commander to be directly involved in day-to-day maintenance support operations.

(2) Administrative and supply delay time will be reduced for missile peculiar items. The employment of dedicated maintenance teams in the area of the supported missile unit will enhance response times and improve operational availability.

(3) The PMO has few combat developers with which to coordinate.

b. DISADVANTAGES:

(1) Authorized stockage list (ASL) and missile stockage list (MSSL)

will necessarily be split out, thus increasing control problems and increasing total quantities to be stocked.

(2) Due to workload fluctuations of units supported, full utilization of the maintenance personnel in the dedicated elements will not be accomplished.

(3) Due to decentralization of the missile peculiar maintenance operation, the maintenance unit commander will find it more difficult to shift resources to meet changing requirements.

3. DESCRIPTION: Readiness Dedicated Area Support, Alternative 3

a. ADVANTAGES:

(1) This concept retains the advantages associated with Alternative 2 concerning the provision of missile peculiar maintenance on a dedicated basis.

(2) The extension of dedicated support for items considered operational ready essential adds the following advantages:

(a) The inclusion of operational readiness essential items in the dedicated support will increase missile operational availability. This essentially assigns high priority, thru dedication, to missile peculiar and operational essential item maintenance.

(b) Maintenance response time for items determined to be operational readiness essential will be improved.

b. DISADVANTAGES:

(1) This concept retains many of the disadvantages associated with Alternative 2.

(a) Support costs will increase. This is caused by the duplication of personnel skills and maintenance equipment necessarily required to

support missile units on a dedicated basis.

(b) Maintenance management becomes increasingly difficult as additional maintenance operations are decentralized. The inclusion of operational readiness essential items to dedicated support will increase the maintenance unit commander's coordination and communication problems with the dedicated elements. His command influence is diminished because of the distance to his subordinate elements.

(c) Support unit ASL's and MSSL will be further fragmented, thus increasing control problems. Also Class IX cross leveling, operational readiness float transactions, and direct exchange operations will become more complex.

(2) Through decentralization of the maintenance personnel in the dedicated elements and the varying maintenance requirements of the supported units, it is likely that full utilization of maintenance skills will not be attained.

(3) The PMO must determine in conjunction with combat developers what the operational readiness essential items of the system are and develop support structure for equipment from other commodity areas.

4. DESCRIPTION: Missile Organic Support, Alternative 4

a. ADVANTAGES:

(1) An organic capability provides the missile battalion commander with an immediately responsive missile maintenance support element. Mission reaction time should not be degraded by the lack of missile maintenance skills or equipment.

(2) Direct support missile maintenance personnel are an active part of the missile unit and as a result are vitally interested in and

familiar with that unit's mission, equipment and problems associated therewith.

(3) Priorities will be inherently high, within the missile battalion, for maintenance of missile peculiar items. The missile unit commander is continuously aware of the tactical priorities within his battalion and can establish and adjust his missile peculiar maintenance priorities accordingly. Also, he is in a position to exert his command influence for enforcement of these priorities within his battalion.

(4) The missile battalion commander, controlling both the tactical and missile peculiar support assets, can influence their utilization. He can shift resources and intensively direct resources towards areas of critical concern with minimum delay.

(5) The support would be located within the battalion structure and could therefore be centrally located so as to provide support with a minimum of delay. The battalion commander can directly influence the location of his maintenance element in order to achieve maximum response. He can establish and enforce reaction time requirements which are commensurate with his tactical situation.

(6) Communications for tactical and support elements are through the same battalion radio and telephone nets which should reduce administrative delay times.

(7) This concept is the least difficult for the PMO as coordination with other commodity areas is not required and the fewest combat development activities are involved.

b. DISADVANTAGES:

(1) Assignment of an organic capability for missile peculiar support

maintenance at the missile battalion level does not satisfy priorities on the broad scale. Although this concept establishes inherently high priorities for missile peculiar maintenance within the battalion, it will not insure conformity with priorities established at higher levels.

(2) Maintenance personnel may not be fully utilized in maintenance mission tasks.

(3) Due to the duplication of tools and maintenance skills required to provide organic missile peculiar maintenance support in missile units support costs will be increased.

(4) The addition of organic missile peculiar maintenance to the missile unit requires the missile unit commander to be directly involved in, and responsible for, day-to-day support maintenance operations in addition to his other critical mission responsibilities.

(5) Due to the limited amount of resources that would be assigned for missile peculiar maintenance at this level, the commander would have very little flexibility in equipment utilization or flexibility in satisfying changes in maintenance requirements. During peak workloads down time due to administration and supply delays will tend to increase.

(6) The number of items placed in the direct exchange program, operational readiness float levels, and the missile support list would be significantly larger from a theater standpoint. Also, cross leveling of supplies would have a small base, at battalion level, from which to work.

5. DESCRIPTION: Readiness Organic Support, Alternative 5

a. ADVANTAGES: The advantages determined for alternative 4, which assigned an organic missile peculiar capability to the missile unit also apply to this alternative. In effect these advantages are enhanced with

the extension of the organic capability to include items considered to be essential for missile operational readiness.

b. DISADVANTAGES:

(1) As with the advantages, the disadvantages of alternative 4 also apply to this alternative.

(2) These disadvantages are compounded with the inclusion of operational readiness essential maintenance in the organic elements. Cost will increase, logistical management and control becomes more complex for the missile unit commander and the problems associated with priorities, Class IX supply, direct exchange, and operational readiness float, are increased.

(3) The PMO must determine in conjunction with combat developers what the operational readiness essential items of the system are and develop support structure for each missile firing battalion to include support for equipment from other commodity areas.

6. DESCRIPTION: Total Organic Support, Alternative 6

a. ADVANTAGES:

(1) This alternative provides maximum organic support under the control of the missile battalion commander, making it the fastest available direct support response.

(2) Direct support maintenance personnel become an active part of the missile unit and become vitally interested in and familiar with the unit's mission, equipment and problems associated therewith.

(3) The missile unit commander will have direct command influence over both his tactical and logistical support elements. He will be able to insure that his internal support priorities are commensurate with his

mission requirements -- both tactical and logistical priorities could be viewed, and decision made by the person responsible for mission accomplishment.

(4) The commander will not have to rely on other managers, outside his direct command, to provide him with maintenance resources. Utilization of the resources available to him would, therefore, be flexible and could be provided expeditiously to the areas where they are required.

(5) The artillery commander would have the same advantages for conventional support items as were cited in alternatives 3 and 4 for missile peculiar and operational readiness essential items.

6. DISADVANTAGES:

(1) Support costs are increased with this alternative. Decentralization of the missile peculiar and operational readiness essential item maintenance to the missile battalion level will result in duplication of skills and equipment in each battalion. Further, the assignment of an organic conventional support capability will duplicate the skills and equipment found in the area maintenance support system.

(2) The missile battalion commander establishes priorities of very limited scope when compared to the theater mission. This tends to establish many priority systems within the theater for both missile and conventional items. In addition, this concept would create numerous individual support structures resulting in inefficient distribution of resources. The theater supply system would have difficulty in effectively satisfying the requirements of these multiple structures.

(3) The PMO must develop in conjunction with the combat developers a support structure for all commodity areas.

(4) The size of a support unit containing all support will restrict proximity to the firing elements.

SECTION VI

CONCLUSIONS

1. Chart 4 translates the advantages and disadvantages of each alternative into a comparison of the alternatives.

a. The factors selected for comparison of alternatives which impact on operational availability are:

(1) Supply dispersion - to include consideration of total quantity of repair parts required and the number of sites required for repair parts stockage. For this analysis a fixed quantity of repair parts is assumed and the impact on the availability of parts when demanded is determined.

(2) Responsiveness - the ability of the tactical commander to influence maintenance priorities and thus influence the reduction of administrative delays due to nonmaintenance activities and maintenance related administrative factors.

(3) Distance - the normal distance between the DS maintenance unit and the missile firing unit.

b. In addition to comparing these operational availability factors for each alternative, the relative economy, e.g. quantities required of test equipment and skilled personnel, and the management difficulty for the PMO of each alternative is predicted.

c. The values assigned to each factor range from one (1) to five (5). In each case one (1) represents the best condition such as the greatest relative economy. In the same manner, five (5) represents the worst condition, such as the greatest distance between supporting and supported elements or the least responsive alternative.

COMPARISON OF ALTERNATIVES

	TOTAL AREA SUPPORT ALT 1	MISSILE DEDICATED AREA SUPPORT ALT 2	READINESS DEDICATED AREA SUPPORT ALT 3	MISSILE ORGANIC SUPPORT ALT 4	READINESS ORGANIC SUPPORT ALT 5	TOTAL ORGANIC SUPPORT ALT 6
Supply Dispersion	1	2	2	3	4	5
Responsiveness	5	4	3	3	1	2
Listance	5	1	1	1	1	2
Relative Economy	1	2	3	2	4	5
PMO Management Difficulty	3	2	4	1	4	5

Relative values range from 1 through 5, where 1 is the best condition and 5 is the worst.

Figure 4

2. In utilizing Chart 4, one must be cautious and realize that the numbers assigned are ordinal. They are relative values which should not stand alone but should be utilized in relation to the values assigned to other alternatives in the factor areas. For example: One (1) value is assigned to Alternative 5 in the area of responsiveness, while the value five (5) is assigned to this same area for Alternative 1. Thus, in comparing these alternatives in the area of responsiveness, Alternative 5 would present a significantly greater beneficial impact on operational availability than Alternative 1. Similarly when analyzing each alternative the values assigned to all factors should be considered collectively as a low value assigned to one factor may be offset by a high value in another. No attempt should be made to sum the values assigned to alternatives to determine which results in the lowest (or best) total value.

4. Considering the relative values for the three primary factors influencing delay time alternative 4 is considered the most preferred. In this particular analysis an optimization of missile operational availability was not sought. The consideration of the necessity for some balance between operational availability and economy, contributes to a selection of Alternative 3 or 4 as the most preferred. However, should conditions prevail whereby either economy, high operational availability, or PMO management difficulty become absolute overriding requirements, this chart can be utilized to select preferred alternatives to meet the particular situation.

SECTION VII

RECOMMENDATIONS

1. During the course of this analysis it became evident that there is no one single support concept best for all missile systems. Improved reliability and maintainability of new systems will continue to impact upon support concepts and the importance of operational availability; relative economy and PM management requirements will continue to vary between systems. For these reasons, it is concluded that a single support concept should not be adopted but that each system should be analyzed on a case by case basis to determine the appropriate support structure consistent with current policy and doctrine.

2. Although this analysis was conducted for missile systems, the methodology could be utilized for other items commodities. The discussion concerning the impact that delay time has on operational availability is appropriate for all commodities and can be utilized for development of other support concepts. The requirement for high operational availability rates for missile systems requires increased emphasis on factor influencing mean downtime; therefore, conclusions reached in this analysis should not be applied universally to other items of equipment. However, by varying the relative weight of the factors considered the general methodology can be extended to these other commodities for selection of DS maintenance structures.

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